

What is claimed is:

1. ~~A motor vehicle all wheel drive system for automatically~~
providing maximum traction and efficiency without wheel slip, with regeneration and retardation for each individual wheel of the vehicle under all loading and driving conditions regardless of driving surface, characterized in that:

the system includes a drive motor for each wheel and means at each wheel operative to sense a loss of traction.

2. A motor vehicle all wheel drive system according to claim 1
wherein:

the system further includes a device for generating energy; each motor receives energy from the generating device and drives a wheel of the vehicle;

the system further includes an energy storage device and a device for directing energy flow in the system; and

the means at each wheel operative to sense a loss of traction comprises means for sensing wheel load and operative;

in response to sensed wheel load to direct energy from the energy generating device to the motor;

in response to a sensed loss of wheel load to reduce the energy supply to the motor and direct the motor energy discharge to the energy storage device; and

in response to a sensed resumption of wheel load to direct regenerative energy from the energy storage device to the motor to assist in powering the motor.

3. A motor vehicle all wheel drive system according to claim 2
wherein each motor is further operative to provide forward and reverse propulsion.

4. A motor vehicle all wheel drive system according to claim 3
wherein the energy from the generating device is utilized to provide forward and

~~reverse motor drive and the stored energy from the energy storage device is utilized to provide only forward motor drive only when the motor is directed to a forward drive mode and the motor is no longer overrunning.~~

5. A motor vehicle all wheel drive system according to claim 3
wherein:

the energy provided to each motor is proportioned to the setting of an acceleration control device for the vehicle; and

the energy provided to each motor is varied in proportion to the turning radius of the wheel powered by that motor when making a turn.

6. A motor vehicle all wheel drive system according to claim 3
wherein the system further includes a brake actuated means for each motor operative to divert the output of the motor to the energy storage device and thereby retard the rotation of the motor.

7. A motor vehicle all wheel drive system according to claim 2
wherein:

the device for generating energy is an engine driven axial piston pump providing fluid pressure and flow rate independent of each other;

each motor comprises a balanced vane type hydraulic motor defining two separate chambers wherein generated pressurized fluid from the generating device is delivered to one chamber of each motor and stored pressurized fluid from the energy storage device is delivered to the other chamber of the motor;

loss of traction is sensed by a drop in system back pressure; and

the energy storage device comprises an accumulator for storing pressurized fluid.

8. A motor vehicle all wheel drive system according to claim 7
wherein the energy directing device includes a first valving device controlled by a

~~vehicle shifting mechanism and operative to shift the fluid flow to the hydraulic motor between forward and reverse mode.~~

9. A motor vehicle all wheel drive system according to claim 7 wherein:

the system includes a tank; and
the energy directing device further includes a second valving device coupled to the first valving device and operative to direct the flow of pressurized fluid from the accumulator to the motor only when the first valving device is in forward mode and the fluid discharge is to tank.

10. A motor vehicle all wheel drive system according to claim 7 wherein:

each pump includes a yoke which is pinned at diametrically opposite ends with the yoke ends free to rotate about the pin connections;

one pinned end of the yoke is the center of a ball which is internally threaded and which is free to rotate relative to the yoke;

an adjusting screw is threadably received in the ball whereby rotation of the screw effects selective pivotal movement of the yoke; and

the other end of the yoke is connected to a lightly spring loaded piston subjected on one face to pump output pressure by way of an internal passage and subjected on an opposite face to motor input pressure by way of an external connection.

11. A motor vehicle all wheel drive system according to claim 10 wherein:

the rotational rate of the axial piston pump is varied in response to variations in the RPM of the vehicle engine;

each axial piston pump includes an electric motor driving the adjusting screw; and

~~the system further includes an electric motor modulating means~~
operative in response to sensed variations in the vehicle steering angle to actuate the adjusting screw and thereby vary the flow rate of the associated axial piston pump.

12. A motor vehicle all wheel drive system according to claim 6
wherein:

the energy storage device comprises an accumulator;
the system further includes a tank; and
fluid pressure from brake actuation is operative to divert motor discharge from the tank to the accumulator.

13. A motor vehicle all wheel drive system according to claim 2
wherein:

the device for generating energy is an electric generator driven by the motor vehicle engine connected to a convertor for modifying the generator output to a form suitable for the vehicle drive motors;
each motor comprises a reversible direct current series motor;
the energy storage device comprises either a battery pack or a capacitor bank;
loss of traction is sensed at each wheel by a DC tachometer circuit; and
each circuit includes a switch operative to divert the output of the respective motor in an overrunning condition to the energy storage device with the switch being actuated by the potential difference across the motor.

14. A motor vehicle all wheel drive system according to claim 3
wherein:

each motor comprises an electric motor; and
the system includes a directional circuit assembly for each motor including a switch controlled by a vehicle shifting mechanism and operative to ~~switch the motor between forward and reverse modes~~.

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~~15. A motor vehicle all wheel drive system according to claim 13 wherein each circuit further includes a switch operative to release energy from the energy storage device to the respective motor only when the motor is in a forward mode and is no longer overrunning.~~

16. A motor vehicle all wheel drive system according to claim 13 wherein:

motor speed is varied by a silicon controlled rectifier circuit operated by input from the vehicle accelerator; and

the speed of each motor is further modified by input from the vehicle steering system superimposed on the accelerator input to vary the motor speed in proportion to the turning radius of the wheel powered by that motor when making a turn.

17. A motor vehicle all wheel drive system according to claim 13 wherein each circuit includes a further switch actuated by a brake of the vehicle and operative to direct the output of the respective motor to the energy storage device.

18. A motor vehicle all wheel drive system including a device for generating energy, a motor receiving energy from the generating device and driving a wheel of the motor vehicle, an energy storage device for receiving energy discharge from the motor, and a directional device for directing energy flow in the system, characterized in that:

the system includes means for sensing wheel load; and

the directional device is operative in response to sensed wheel load to direct energy from the energy generating device to the motor and is operative in response to a sensed loss of wheel load to direct the motor energy discharge to the energy storage device.

~~19. A motor vehicle all wheel drive system according to claim 20 wherein:~~

~~the sensing system is operative in response to a sensed resumption of wheel load to direct regenerative energy from the energy storage device to the motor to assist in powering the motor.~~

20. A motor vehicle all wheel drive system comprising:

- a device for generating energy;
- a motor receiving energy from the generating device and driving a wheel of the motor vehicle;
- means for sensing wheel load; and
- means operative in response to a sensed loss of wheel load to reduce the energy supply to the motor from the generating device to a level matching the wheel load requirements.

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